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Tetra Tech EM Inc.

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March 21, 2001

Mr. Pete Stevenson
On-Scene Coordinator
U.S. Environmental Protection Agency, Region VIII
999 18th Street, Suite 600, Mail Code: 8EPR-ER
Denver, Colorado 80202-2405

Subject: START2, EPA Region VIII, Contract No. 68-W-00-118, TDD No. 0101-0008. Imminent and Substantial Endangerment to Human Health and Environment Due to Metals Contamination at American Fork Canyon Sites, Uinta National Forest, Utah County, Utah

Dear Mr. Stevenson:

This endangerment assessment describes human health and environmental risks associated with metals contamination at two mine sites in American Fork Canyon, Uinta National Forest in Utah County, Utah. Health and environmental risks at the site include impacts to human health through recreational use of the mine sites and resulting inhalation, dermal and ingestion exposure to metals-contaminated tailings and soils. In addition, a potential for human exposure to metals exists through the consumption of locally caught contaminated fish. Environmental impacts include the potential effects of contaminated soil and mine runoff on terrestrial and aquatic ecological receptors.

BACKGROUND

The Dutchman Flats site is located adjacent to the North Fork of the American Fork River in Utah County, Utah, and consists of a mill site, mine waste dump, and tailings pond. The Pacific Mine site is also located adjacent to the North Fork of the American Fork River, just north of its confluence with the Dry Fork. It consists of the Pacific Mine waste pile, the Pacific Mill, and the Pacific Mill tailings pond.

Both the Dutchman Flats and Pacific Mines are historical lead mines and have extensive piles of mine and mill tailings containing high levels of lead (up to 99,999 parts per million [ppm]) and arsenic (up to 3,700 ppm). About 46,000 tons of tailings are present at the Pacific Mine site alone. In addition to high levels of lead and arsenic in tailings, elevated levels of lead, arsenic, and zinc have been found in fish collected downstream of the Pacific Mine site, indicating that runoff from the Pacific Mine site is contaminating the American Fork River.

Human exposure to these metals is currently occurring, because both the Dutchman Flats and Pacific Mine areas are used extensively for recreation, including camping, hiking, picnicking, mine exploration, hunting, fishing, and all-terrain vehicle (ATV) and four-wheel drive vehicle use. Many of these activities can be expected to generate high levels of airborne contaminated dust, resulting in a likelihood for significant inhalation exposure to the recreational user.

The level of use of the area generally is very high, with about 1.2 million visitors entering the American Fork Canyon each year (USDA 2000). During the summer, use of the Dutchman Flats and Pacific Mine sites often occurs daily, presenting a particularly high potential for unsafe exposure during that time of year.

DATA EVALUATION

Analytical data used as the basis for this assessment were obtained from the November 20, 2000 *American Fork Canyon Watershed Reclamation Project: A Preliminary Investigation Report* prepared by the U.S. Department of the Interior (DOI 2000) as well as the action memorandum prepared for the Dutchman Flats site (USDA 2000). These data include the results of the analysis of mine waste and tailings at both Dutchman Flats and Pacific Mine. In addition, unpublished data on metals concentrations in local fish and streams were also reviewed (written communication from Pete Stevenson, U.S. Environmental Protection Agency [EPA], Region VIII).

Concentrations of lead in soil and tailings at the Pacific Mine site average 17,000 ppm, with levels as high as 99,999 ppm in some areas. Lead was found at high levels in virtually all samples collected. Arsenic was detected less frequently, but at levels as high as 3,700 ppm in some areas. At the Dutchman Flats site, lead concentrations as high as 6.8 percent (68,000 ppm) were detected in the tailings piles. Arsenic levels were as high as 2,440 ppm. These elevated lead and arsenic levels can be compared to natural background levels for these elements of about 10 and 5 ppm, respectively (EPA 1983). All other concentrations of metals detected in soils, tailings, and mine waste were found to be below the corresponding EPA Preliminary Remediation Goal (PRG) for industrial use and were not evaluated further in this memorandum. No PRGs have been established by EPA for recreational use at this site.

In addition to these high levels of lead and arsenic in soil and tailings, elevated levels of lead, arsenic, and zinc have been found in fish caught downstream of the Pacific Mine site. For example, the average concentration of lead in four fish caught upstream of the Pacific Mine site was 0.078 ppm, while the average in downstream fish was 0.671 ppm, representing almost a 10-fold increase in concentrations of lead in fish caught downstream of the Pacific Mine site.

HUMAN HEALTH RISKS

A preliminary evaluation of human health risks at the two sites was conducted based primarily on the comparison of soil and tailings material concentrations of arsenic and lead to PRGs developed for these metals. The PRGs were developed for the specific protection of the recreational user, the most likely human receptor population expected to be exposed to these metals. These PRGs were derived based on the most significant exposure pathways, soil ingestion, dust inhalation, and dermal contact, as described in detail below. In addition, human exposure that may occur through ingestion of contaminated local fish was also evaluated.

Conceptual Site Model

A conceptual site model (CSM) was prepared for the American Fork Canyon sites (Figure 1). The CSM graphically illustrates the relationship between contaminant sources, release mechanisms, exposure pathways, and human population receptors. Figure 1 shows that metal contaminants at the sites derive from tailings piles, waste rock piles, and mill sites. Contaminants are released from these sources into the surrounding soils by wind erosion, surface runoff and infiltration. The primary human population receptor is considered to be the recreational user who is exposed to metal contaminants primarily through inhalation of airborne dust, incidental soil ingestion, and dermal contact with soil. Because the present analysis is only a screening evaluation, and as a result of limitations in the available data, a quantitative analysis of all potential exposure pathways was not conducted.

Human Exposure to Lead in Soil and Tailings Material

Health risks posed by lead in soil are evaluated using mathematical models to predict blood lead concentrations in children or adults. For residential exposure scenarios, the child is the relevant receptor and the *Integrated Exposure Uptake Biokinetic Model for Lead in Children* (IEUBK) is used (EPA 1994). For nonresidential exposure scenarios, as would be applicable for these mine sites, the adult is the direct receptor and the interim *Adult Lead Methodology* (ALM) is used to evaluate lead risks (EPA 1996). Both models use site-specific exposure parameters to derive a residual soil level of lead considered to be protective of human health.

According to the ALM, the pregnant woman is the direct receptor. However, lead exposure to the fetus of a pregnant woman is actually the receptor upon which the predicted protective soil lead concentration, the PRG, is based. Since the fetus is considered the more sensitive to the effects of lead than are adults or older children, protection of the fetus is considered to result in protection of adults and children as well. The ALM model is used to predict a lead concentration in soil such that less than 5 percent of pregnant women exposed to that soil concentration would experience a fetal blood lead level of greater than 10 micrograms per deciliter (μg/dl).

The ALM model incorporates several exposure parameters that can be modified on a site-specific basis to develop a site-specific PRG. In particular, the ALM model was not specifically developed to address a recreational exposure scenario as would be applicable in this case. Therefore, this model must be adjusted using exposure parameters relevant to recreational use rather than the default commercial exposure scenario. The two parameters that must be modified to accommodate a recreational exposure scenario include the soil ingestion rate and the number of days per year an individual would be exposed. The default value used in the ALM model for the soil ingestion rate is 50 milligrams per day (mg/day). This value, however, is based on the limited soil exposure that would normally occur for an office or retail worker. For recreationists involved in hiking, camping, and riding vehicles over the tailings piles, however, it can be expected that the incidental soil ingestion rate would be much higher. EPA recommends use of 100 mg/day as an "appropriate default value for contact intensive scenarios" (EPA 1999). Therefore, this value was used in the ALM model for the daily rate of incidental soil ingestion. The exposure frequency, or number of days per year (days/yr) an individual would be exposed to the mine site soils, was assumed to be 45 days/yr. This value is based on the conservative assumption that a recreationist might access these areas every other day during the three primary summer months of June, July, and August.

Modifying the ALM model as described results in a lead PRG range of 2,161 to 3,760 ppm. This range of PRG levels results because the ALM model uses two different assumptions about population variability in response to lead exposure. Where a more genetically homogeneous population is the exposed population, the higher PRG can be used. However, since there is no information regarding the local population characteristics with respect to this parameter, it is most health-protective to consider all soil with lead levels greater than 2,161 ppm a potential health risk.

It should be noted that the ALM model does not take into account either the dermal or inhalation exposure pathways as a source of exposure to lead. This is because the contribution via these pathways is assumed to be insignificant relative to the soil ingestion pathway. However, this assumption may not be true for recreationists at these mine sites. Riding ATVs, motocross bikes, or four-wheel drive vehicles over the tailings piles is likely to produce very high levels of airborne lead-contaminated dust that individuals may inhale. Under these circumstances, the contribution of lead via the inhalation pathway may be significant. Further quantitative evaluation of the contribution of the inhalation pathway would require site-specific information on airborne levels of lead during these recreational activities and modification of the ALM model to allow explicit consideration of the inhalation pathway. The same considerations apply to the dermal pathway. Although dermal absorption of lead is typically very low under most circumstances, dermal loading and therefore exposure may be much higher than is typical based on the recreational uses observed at this site.

Toxicity of Lead

The following information was obtained from the Agency for Toxic Substances and Disease Registry (ATSDR) (ATSDR 2000).

Lead is commonly found at mining sites in the form of galena (PbS), cerussite ($PbCO_3$), and anglesite ($PbSO_4$) ores. Lead is also associated with production and disposal of storage batteries, and antiknock fuel additives, and has been widely used for pigments in paints as well as in glazes and coloring on ceramic pottery.

The normal daily intake of lead for an adult is approximately 10 to 20 micrograms (ug)/day. Normal adults absorb approximately 10 percent of an oral dose of a lead compound, depending on the particular lead species and the age of the individual. Absorption in children, however, can be as high as 50 percent. High dietary levels of calcium and phosphorus can significantly reduce lead uptake by interfering with uptake mechanisms in the gastrointestinal tract. In contrast, fasting increases the absorption of ingested lead.

In the lung, about half the lead that reaches the alveoli is absorbed into the systemic circulation. Limited amounts of inorganic lead may also be absorbed through the skin when it is applied in high concentrations. Compared with inorganic forms, organic lead compounds are more readily absorbed through the skin.

Most absorbed lead is deposited in the mineral matrix of bone. After lead has been incorporated in the bone matrix, excretion (mostly in the urine) is very slow. The half-life of bone lead is about 20 years. Lead apparently continues to accumulate in humans throughout life.

Large single doses of lead produce fatigue, sleep disturbances, and constipation, followed by colic, anemia, and neuritis. Chronic lead poisoning produces loss of appetite, metallic taste, constipation and obstipation, anemia, pallor, malaise, weakness, insomnia, headache, nervous irritability, muscle and joint pains, fine tremors, damage to kidney tubules and in cases of high, long-term exposure, chronic nephritis. Other effects include certain muscular weaknesses ("wrist drop") and lead encephalopathy.

The most commonly used indicator of lead exposure is the whole blood lead level. Toxic effects of lead may occur at levels so low that a threshold is effectively nonexistent. In other words, there may be no completely safe exposure to lead for children. Other signs of low-dose lead toxicity include learning deficits and growth retardation in children and hypertension in middle-aged men. Exposure to low doses of lead in childhood causes long-lasting effects that are thought to be irreversible. Sensitivity to the adverse effects of lead extends from fetal development to the cessation of growth after puberty. At very high exposure levels, lead may produce severe reproductive toxicity, inducing premature deliveries and spontaneous abortions in women and sterility in men.

Human Exposure to Arsenic in Soil and Tailings

Elevated levels of arsenic were also found in tailings at both mine sites. In order to evaluate the significance of these elevated levels, a PRG was developed for a hypothetical adult recreationist receptor using the following equation:

$$PRG = \frac{TR \times BW \times AT}{EF \times ED\left[\left(\frac{IRS \times BA \times CSF_o}{10^6\ mg/kg}\right) + \left(\frac{SA \times AF \times ABS \times CSF}{10^6\ mg/kg}\right) + \left(\frac{IRA \times CSF_i}{PEF}\right)\right]}$$

where:

TR	=	target cancer risk (1E-06)
BW	=	body weight (kilograms [kg])
AT	=	averaging time (days)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BA	=	bioavailability (unitless)
IRS	=	soil ingestion rate (mg/day)
CSF_o	=	cancer slope factor for arsenic (oral exposure route) ($(mg/kg/day)^{-1}$)
CSF_i	=	cancer slope factor for arsenic (inhalation exposure route) ($(mg/kg/day)^{-1}$)
SA	=	skin surface area for an adult (square centimeters [cm^2])
AF	=	soil adherence factor (mg/cm^2)
ABS	=	dermal absorption efficiency of arsenic (unitless)
IRA	=	inhalation rate (cubic meters [m^3]/day)
PEF	=	particulate emission factor (m^3/kg)

The above equation is a slightly modified version of the EPA Region 9 equation used to calculate PRGs for industrial exposure of adults to carcinogenic contaminants in soil (EPA 2000a). It explicitly considers exposure that occurs through soil ingestion, dermal contact with soil, and inhalation of resuspended particulates. This equation can be adjusted for application to the recreational exposure scenario at these mine sites by using alternative values for several of these exposure parameters. Target cancer risk values of 1E-06, 1E-05, and 1E-04 were used to represent the range of risks that EPA may consider acceptable at contaminated sites. Consistent with the lead evaluation described above, the soil ingestion rate was increased to 100 mg/day, the default value recommended by EPA for activities that involve a high level of soil contact (EPA 1999). In addition, a bioavailability correction factor of 80 percent was used since the arsenic at these sites is derived from mining wastes. The 80 percent value is consistent with Region VIII recommendations (EPA 2000b). The exposure frequency was changed to 45 days/year, corresponding to use of the area every other day during the three summer months. Exposure duration was assumed to be 10 years. The dermal absorption efficiency, soil adherence factor, and adult skin surface area were assumed to be 0.03, 0.2 mg/cm^2 and 5,700 cm^2, consistent with Region 9 PRG guidance (EPA 2000a). The cancer slope factor is 1.5 for the oral route and 15.1 for the inhalation route. An inhalation rate of 6.7 m^3/day was used based on the assumption that most recreationists would typically spend just the day at the mine sites. This value is one-third of the standard 20 m^3/day assumed for a residential adult receptor. Using these protective exposure parameter values, a cancer risk-based PRG for arsenic in the adult of 23 ppm was calculated at the 1E-06 target cancer risk level. Attachment A shows the calculations used to the derive the PRG for arsenic of 23 ppm. Corresponding PRG values at the 1E-04 and 1E-05 target risk levels are 2,300 and 230 ppm, respectively. For maximum protection of public health, tailings materials and soils that contain higher than 23 ppm arsenic should either be removed or should be subject to institutional controls to prevent human exposure.

An important caveat to the above calculation is that the particulate emission factor does not take into account resuspension of soil caused by mechanical disturbance, but only that resulting from wind erosion. Since it is known that recreationists at these sites drive ATVs and other motorized vehicles over and around the tailings piles, significant mechanical resuspension of contaminated dust is likely. Thus, this evaluation of the inhalation pathway using the particulate emission factor (PEF) approach is likely to significantly underestimate exposure to arsenic via inhalation. A more accurate evaluation of the inhalation pathway would require site-specific information on actual levels of dust to which ATV riders are being exposed.

Toxicity of Arsenic

The following information was obtained from ATSDR (2000).

Arsenic is a naturally occurring element with widespread distribution. In most regions natural levels of arsenic in soil are less than 10 ppm. Arsenic is used in metallurgy to harden copper, lead, and alloys; in the manufacture of certain types of glass; and in medical applications. Because arsenic is present in many mineral ores, it is frequently found concentrated at mining sites.

Human exposure to arsenic occurs primarily through chronic oral ingestion of a variety of organic and inorganic forms of arsenic. Food constitutes the largest source of daily exposure to arsenic. Humans consume an average of 25 to 50 µg/day arsenic from this source. The particular form of arsenic ingested is a critical factor. Trivalent arsenic compounds are more toxic than pentavalent forms. However, the pentavalent form is most commonly found in the environment because natural oxidation processes in the environment favor it.

Water-soluble arsenic is efficiently absorbed from the gastrointestinal tract. Reaching the systemic circulation, trivalent arsenic is detoxified in the liver by conversion to methylarsenic acid and dimethylarsenic acid, which are the principal forms excreted in the urine. The body burden of arsenic can reach considerable levels since it can be sequestered in nails, hair, bones, teeth, skin, liver, kidneys, and lungs.

The adverse health effects produced by arsenic are highly dose dependent. For example, at low concentrations, arsenic may be an essential nutrient and substitute for phosphorus in key biochemical reactions. At high levels, however, arsenic has been recognized as an effective human poison. At toxic levels, it produces severe gastrointestinal irritation, including hemorrhage, and a form of peripheral arteriosclerosis known as blackfoot disease.

Exposure to low levels of arsenic can produce malaise and fatigue, gastrointestinal distress, anemia and basophilic stippling, and neuropathy. The most characteristic pathological effects of chronic arsenic poisoning, however, are skin lesions, particularly plantar and palmar hyperpigmentation and hyperkeratotic lesions. Although these lesions in themselves do not pose a significant health concern, they may ultimately develop into malignant skin cancers and metastasize to other parts of the body.

Health Risks Due to Contaminated Fish Consumption

In addition to the health risks posed by contaminated soil and tailings, fish collected at sites downstream of the Pacific Mine site in the American Fork River show elevated concentrations of lead, arsenic, and zinc. Fish were not analyzed for mercury. The Food and Drug Administration (FDA) has not established safe levels (action or guidance levels) for detected metals in fish per se, but has established them for lead and arsenic in crustaceans and shellfish. The guidance levels for arsenic are 76 in crustaceans and 86 ppm in shellfish. The corresponding guidance levels for lead are 1.5 in crustaceans and 1.7 ppm in shellfish. By comparison, maximum levels of lead and arsenic detected in locally caught fish, although significantly elevated downstream of the mine sites, are still less than 1 ppm.

ECOLOGICAL RISKS

In addition to the screening assessment of human health risks associated with lead and arsenic in tailings material at these sites, a preliminary evaluation of ecological impacts was conducted for arsenic, cadmium, copper, lead, mercury, and zinc. This screening evaluation was based on results of sampling of surface water, soil, and macroinvertebrates, and also included consideration of potential effects on soil invertebrates, soil microbes, terrestrial plants, and fish. No sediment samples were collected; therefore impacts related to potential sediment exposure could not be evaluated and may be underestimated.

This screening evaluation also did not consider wildlife exposure that may occur through the ingestion of contaminated prey or forage. Ingestion of contaminated plants or fish by wildlife may be a significant source of contaminant exposure for wildlife in the area.

Conceptual Site Model

A CSM that illustrates the relationship between contaminant sources, release mechanisms, exposure pathways, and potential ecological receptors is shown in Figure 1. Figure 1 is as described above for the human receptors except that the receptor populations include both terrestrial and aquatic ecological receptors. Terrestrial wildlife receptors are expected to be exposed to contaminants primarily through soil and food ingestion (for example, ingestion of contaminated forage). The primary exposure pathways for aquatic receptors are expected to be respiratory uptake, sediment and food ingestion, and dermal absorption. Because the present analysis is only a screening evaluation, and because of limitations in the available data, a quantitative analysis of these potential exposure pathways was not conducted.

Impacts to Terrestrial Life

Potential impacts to terrestrial wildlife were evaluated based on comparison of available chemical-specific toxicological benchmarks (TB) for soil to metal concentrations detected at the mine sites. TB values are available for terrestrial plants, soil invertebrates, and soil microbes (Table 2). TBs are not readily available for mammalian or avian wildlife at this time. However, TBs for plants and soil invertebrates are virtually always lower than soil TBs derived for mammals and birds. Therefore if site soil concentrations are below the TBs for soil invertebrates, soil microbes, and plants, birds and mammals can also be expected to be protected.

Table 3 shows typical ranges of metals found at the American Fork Canyon at the Dutchman Flats site, the Dutchman Flats smelter site, and the Pacific Mill site. Also shown in Table 3 is the frequency of sample locations at these sites where the soil concentration exceeded the corresponding soil TB for earthworms. Table 3 shows that soil concentrations of metals at most locations sampled exceed the soil TB for earthworms. Comparison of Table 3 to Table 2 shows that the range of metals concentrations also exceeds the TB for protection of soil microbes and terrestrial plants. This comparison therefore indicates that the likelihood of significant adverse impacts to these ecological receptors posed by metals in soil at these sites.

Impacts to Aquatic Life

Stream macroinvertebrate populations were dramatically reduced just downstream of the mine sites. For example, macroinvertebrate populations were reduced from 14,000 individuals per square meter upstream of these sites to less than 4,000 downstream of the sites (USDA 2000). These findings strongly suggest that metals-contaminated runoff entering the North Fork of the American Fork River may be causing adverse impacts to stream fauna. This runoff may also be affecting populations of Bonneville cutthroat trout, a State of Utah conservation species, and the spotted frog (*Rana luteiventris*), a candidate for endangered species listing. Note that the presence of the spotted frog at these mine sites has not been verified. No studies of possible effects on the abundance of the Bonneville cutthroat trout or other native fish species have been conducted.

That the above adverse effects on stream fauna are being caused by mine runoff contamination is supported by the fact that lead and zinc concentrations in runoff from these sites are significantly above EPA ambient water quality criteria (AWQC) for the protection of aquatic life. The EPA AWQC for arsenic, cadmium, copper, lead, mercury, and zinc are shown in Table 2. Table 2 shows the criteria maximum concentration (CMC), which is "an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect" and the criterion continuous concentration (CCC), which is "an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect."

Concentrations of metals were below detection limits in most reaches of the American Fork proper, and average concentrations were below the corresponding AWQC. However, metals concentrations did exceed AWQC in tributaries to the American Fork and in surface runoff. For example, zinc levels considerably in excess of 120 μg/liter(L) (total zinc) (CCC/CMC) were detected at 5 of 20 locations sampled in tributaries of the American Fork River downstream of these mine sites. Lead and cadmium also exceed their corresponding CCC at 4 of 20 and 5 of 20 locations, respectively, in American Fork tributaries. Surface runoff concentrations of metals also significantly exceed corresponding AWQC at many locations. Zinc concentrations found in Pacific Mine runoff range up to 2,520 micrograms per liter (μg/L) (total zinc) while lead and cadmium concentrations range up to 130 μg/L lead and 27.1 μg/L cadmium respectively (as total metal).

CONCLUSIONS

Metals-contaminated soil and mine waste (tailings) present imminent health risks to the public and the environment at the Dutchman Flats and Pacific Mine sites. In particular, inhalation, dermal, and ingestion exposure of recreationists accessing these areas is expected to result in unsafe exposure to lead and arsenic. PRGs were developed for arsenic and lead using standard EPA methods. Comparison of these PRGs to levels of lead and arsenic detected in site soils and tailings materials indicates that many areas of these sites must be considered unsafe for recreational use. Levels of lead, arsenic, and zinc are elevated in fish collected downstream of these sites. However, these levels are still less than available safe levels (guidance levels) established by FDA for metals in seafood. Metals-contaminated mine runoff is adversely affecting stream fauna as indicated by 1) reduced macroinvertebrate populations downstream of these sites, and 2) by significant exceedances of AWQC for zinc, lead, and cadmium in mine runoff, the American Fork River, and tributaries of the American Fork River. The lack of sediment data and data regarding concentrations of contaminants in forage is likely to result in an underestimate of wildlife exposure to site contaminants.

Two copies of this letter report are submitted for your review and comments. If you have any questions, please call me at 303-382-8799.

Sincerely,

Paul Damian

Paul Damian PhD, MPH, DABT
Program Manager
Risk Asssessment and Toxicology

cc: Lisa Gard/UOS
File/UOS
File/TTEMI

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Table 1

Human Health Exposure Parameters Used to Calculate Arsenic and Lead PRGs

Exposure Parameter	Notation	Units	Value: Arsenic PRG	Value: Lead PRG	Reference
Adult body weight	BW	kg	70	70	EPA (2000a)
Averaging time	AT	days	25,550	NA	EPA (2000a)
Exposure frequency	EF	days/yr	45	45	See text.
Exposure duration	ED	yr	10	NA	See text.
Bioavailability	BA	unitless	0.8	0.12	EPA (2000b);EPA (1996)
Adult soil ingestion rate	IRS	mg/day	100	100	EPA (1999)
Cancer slope factor-oral	CSFo	risk per mg/kg/day	1.5	NA	EPA (2000c)
Cancer slope factor-inhalation	CSFi	risk per mg/kg/day	15.1	NA	EPA (2000c)
Adult skin surface area	SA	cm^2	5,700	NA	EPA (2000a)
Skin adherence factor	AF	mg/cm^2	0.2	NA	EPA (2000a)
Dermal absorption efficiency	ABS	unitless	0.03	NA	EPA (2000a)
Adult inhalation rate	IRA	m^3/day	6.7	NA	See text.
Particulate emission factor	PEF	m^3/kg	1.32E+09	NA	EPA (2000a)

NA = Not applicable.
kg = kilograms
mg = milligrams
cm^2 = square centimeters
m^3 = cubic meters

Table 2

Toxicological Benchmarks for Metals at Dutchman Flats

Metal	Terrestrial Plants[1] (mg/kg soil dw)[2]	Soil Invertebrates[3] (earthworm) (mg/kg soil dw)	Soil Microbes[4] (mg/kg soil dw)	AWQC[5] CMC[6] (ug/L)	AWQC[5] CCC[7] (ug/L)
Arsenic	10 to 315	60	100	340	150
Cadmium	3 to 100	20	20	4.3	2.2
Copper	60 to 125	50	100	13	9
Lead	50 to 1,000	500	900	65	25
Mercury	5 to 35	0.1	30	1.4	0.77
Zinc	50 to 500	200	100	120	120

[1]From ISSI (1999).
[2]soil dw = soil dry weight basis
[3]From Efroymson et al. (1997).
[4]From Efroymson et al. (1997).
[5] AWQC = ambient water quality critiera (from Federal Register, Vol. 63, No. 237, December 10, 1998).
[6] CMC = criteria maximum concentration (an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect).
[7] CCC = criterion continuous concentration (an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect).
ug/L = micrograms per liter
mg/kg = milligrams per kilogram

Table 3

Typical Range of Metals Concentrations in Soil at American Fork Canyon

Site	Soil Concentration (mg/kg) Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
Dutchman Flats	51 to 2,440 (12/16)[1]	45 to 217 (9/16)	208 to 1,190 (7/16)	156 to 68,454 (14/16)	71 to 297 (2/16)	301 to 54,447 (16/16)
DF Smelter	92 to 1160 (3/3)	58 (1/3)	227 to 4,189 (3/3)	3,629 to 38,400 (3/3)	23 (1/3)	1,140 to 23,296 (3/3)
Pacific Mill	BD to 3,667 (4/23)	BD to 341 (2/9)	BD to 2,400 (14/23)	304 to 99,994 (22/23)	BD to 8,486 (20/23)	341 to 20,890 (23/23)

[1]Frequency of sample locations exceeding soil toxicological benchmark for earthworms.

BD = below detection

mg/kg = milligram per kilogram

ATTACHMENT A

PRG CALCULATION FOR ARSENIC

CALCULATION / WORK SHEET

Tetra Tech EM Inc.

SHEET 1 OF 1

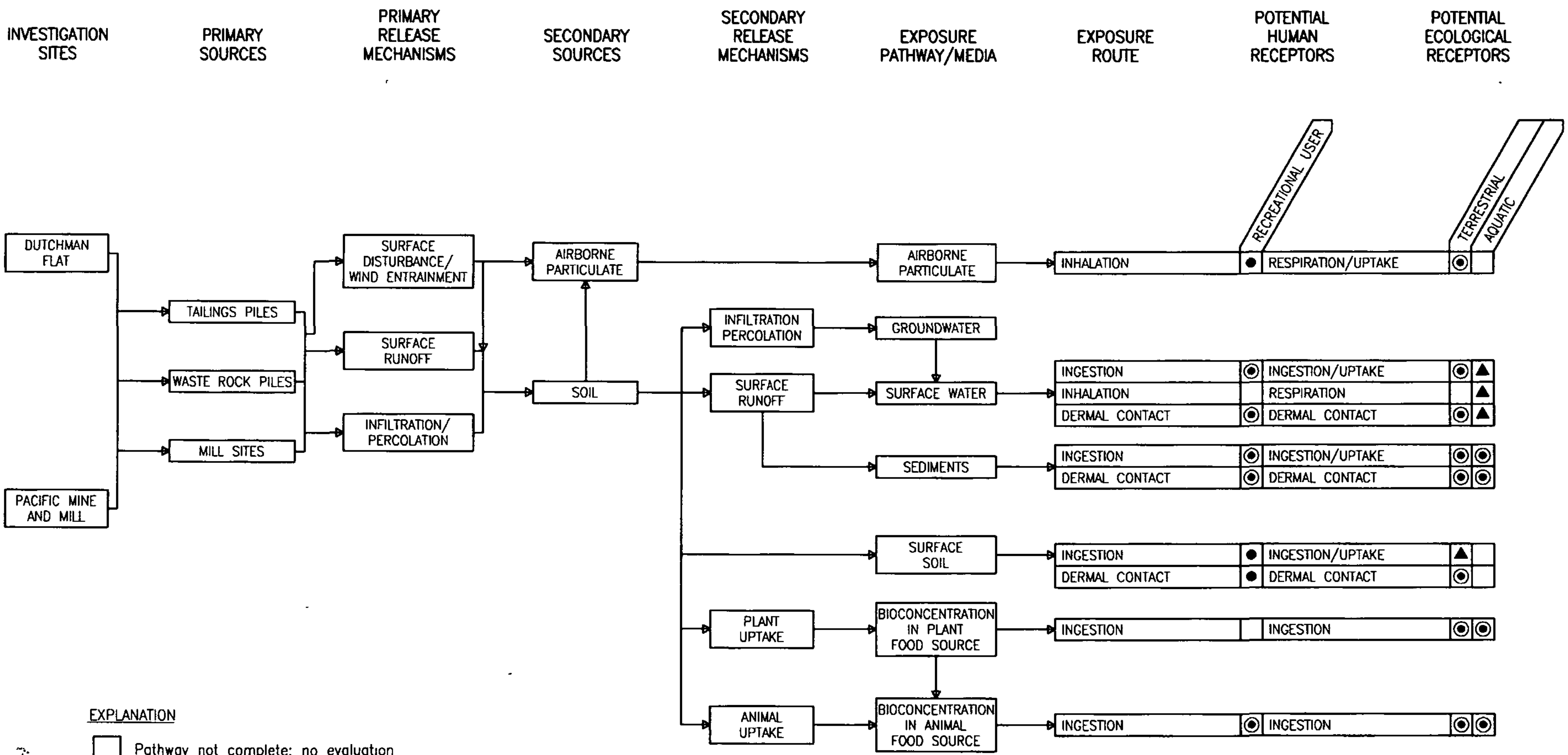
PROJECT:		COMPONENT/SYSTEM.	
Dutchman Flats/Pacific Mine Sites		PRG Calculation for Arsenic	
PREPARED BY	DATE	CHECKED BY	DATE
Paul Damian	3/2/01	S. Kennedy	3/7/01

$$PRG = \frac{(1E\text{-}06)(70\ kg)(25550\ days)}{\left(\frac{45\ days}{yr}\right)(10\ yrs)\left[\frac{\left(\frac{100\ mg}{day}\right)(0.8)(1.5)}{10^6\ \frac{mg}{kg}} + \frac{(5{,}700\ cm^2)\left(\frac{0.2\ mg}{cm^2}\right)(.03)(1.5)}{10^6\ \frac{mg}{kg}} + \frac{(6.7\ m^3/day)(15.1)}{(1.316E9\ m^3/kg)}\right]}$$

$$= 23.2\ mg/kg$$

URS Operating Services
START2, EPA Region VIII
Contract No 68-W-00-118

American Fork Canyon Sites
Revision 0
Date 03/2001



EXPLANATION

- ☐ Pathway not complete; no evaluation
- ● Pathway complete and selected for quantitative evaluation
- ▲ Pathway complete and selected for screening evaluation
- ◉ Pathway complete but data are lacking for quantitative and screening evaluations

Endangerment Assessment
UOS Job No 75-10108.00

American Fork Canyon Sites
Utah County, Utah

Human Health and Ecological Conceptual Site Model

Figure 1

March 2001

URS OPERATING SERVICES

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